

DBP – Image Guided Prostate Interventions

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Prostate cancer

- One of every 6 men in the U.S. will be diagnosed
- 234,460 new cases in 2006
- Incidence will double by 2015
- ~1 million needle biopsies per year
- ~60,000 brachytherapy procedures per year



Image guided prostatic needle placement

- Diagnosis (core needle biopsy)
- Deliver localized therapy (seeds, injection)
- Imaging research validation (irrefutable ground truth by histopathology of tissue collected from the same location)



Image guidance – MRI

PROS

- Sensitivity in detecting soft tissue abnormalities
- Excellent visualization of prostate and normal tissues
- Morphological, functional and molecular imaging

CONS

- Expensive
- Limited availability



Image guidance – TRUS

PROS

- Reasonable visualization of prostate and normal tissues
- Cheap
- Widely available
- Harmless

CONS

- Limited (poor) sensitivity
- Operator dependent
- Invasive



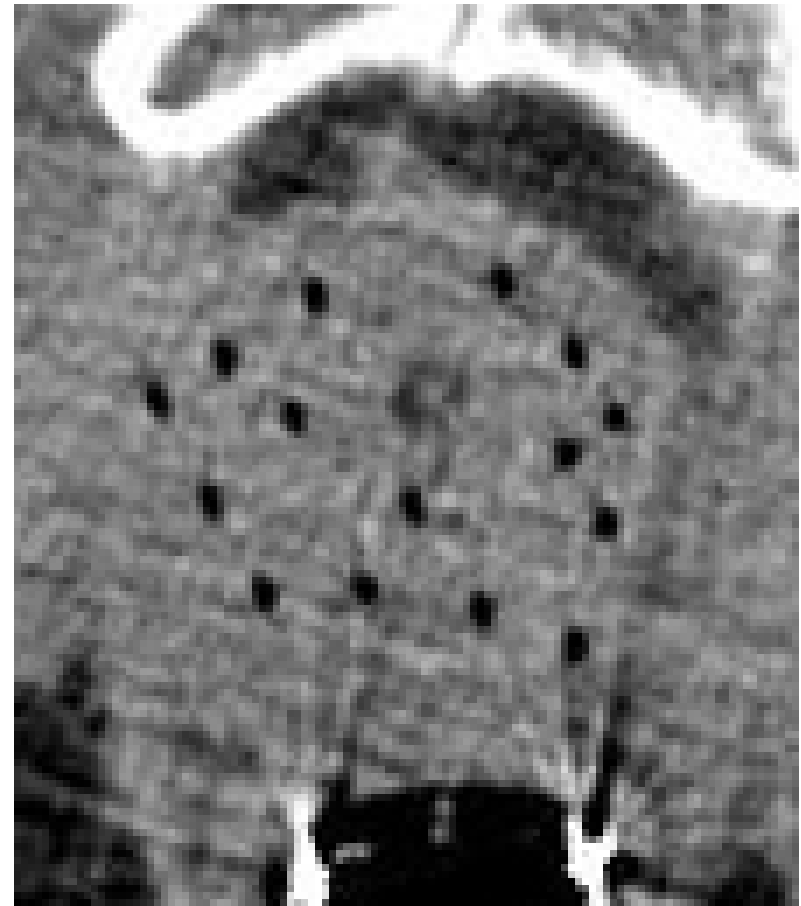
Image guidance – CT

PROS

- Available in RadOnc
- Useful in dose planning

CONS

- Poor sensitivity
- Poor contrast
- Harmful
- Not real time
- Moderately expensive



* Not used outside EBRT & post implant dosimetry



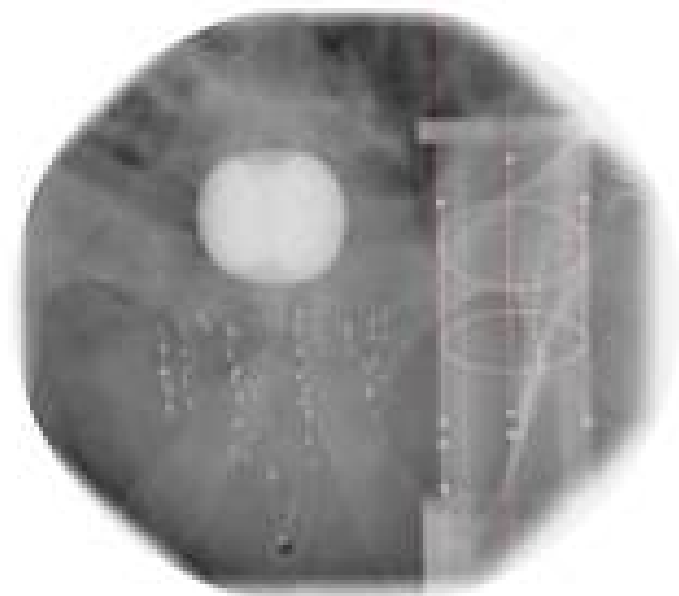
Image guidance – C-arm fluoro

PROS

- Cheap
- Widely available (70% of brach practitioners have in the OR)

CONS

- Limited soft tissue contrast
- Harmful radiation
- Extremely difficult to use computationally



* Not used outside prostate brachytherapy



Two facts of life

1. **Modalities coexist**
2. **Fusion is necessary**



Project families

	Trans-rectal	Trans-perineal
MR	Biopsy (coming: injections)	Biopsy/Brachy
TRUS	Ablation (coming: biopsy)	Brachytherapy



Project #1: Transrectal interventions in closed MRI

Engineering:

The Johns Hopkins University

Clinical:

- (1) National Institutes of Health
- (2) (2) Princess Margaret Hospital, Toronto
- (3) Memorial Sloan Kettering Cancer Center

Funding

NIH/NIBIB 1R01EB002963, PI Fichtinger
(2 more years)



In-scanner robotic assistant



37 patients treated

- A. Krieger, R. Susil, C. Menard, J. Coleman, G. Fichtinger, E. Atalar, L. Whitcomb. Design of A Novel MRI Compatible Manipulator for Image Guided Prostate Interventions. IEEE Transactions on Biomedical Engineering, February 2005.
- Ménard et al. An Interventional MRI Technique for the Molecular Characterization of Intra-Prostatic Dynamic Contrast Enhancement. Molecular Imaging, January-March 2005, 4(1): 63-66
- Susil et al., Transrectal Prostate Biopsy and Fiducial Marker Placement in a Standard 1.5T MRI Scanner, J Urol. 2006 Jan;175(1):113-20.

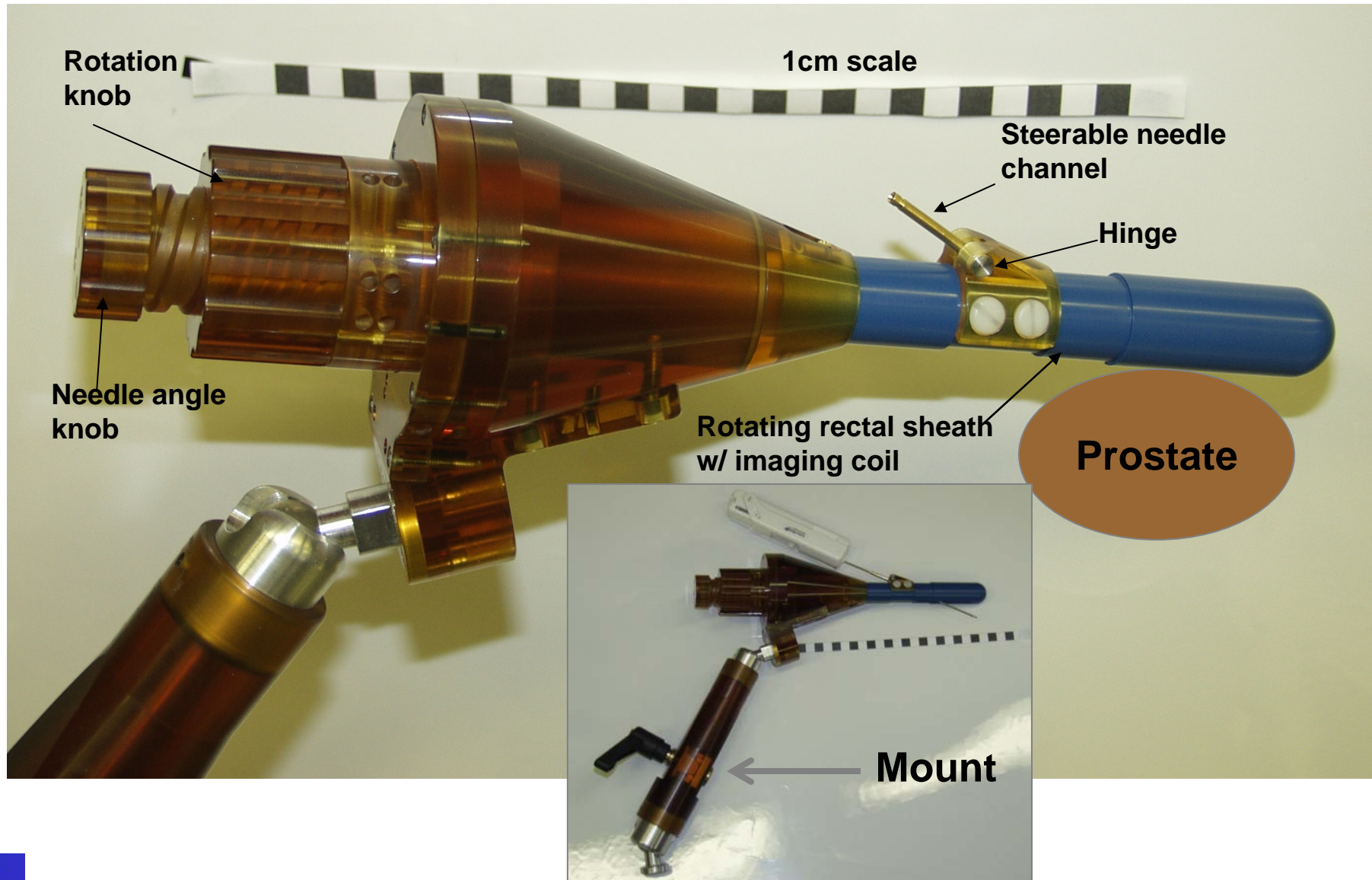


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Robot close-up



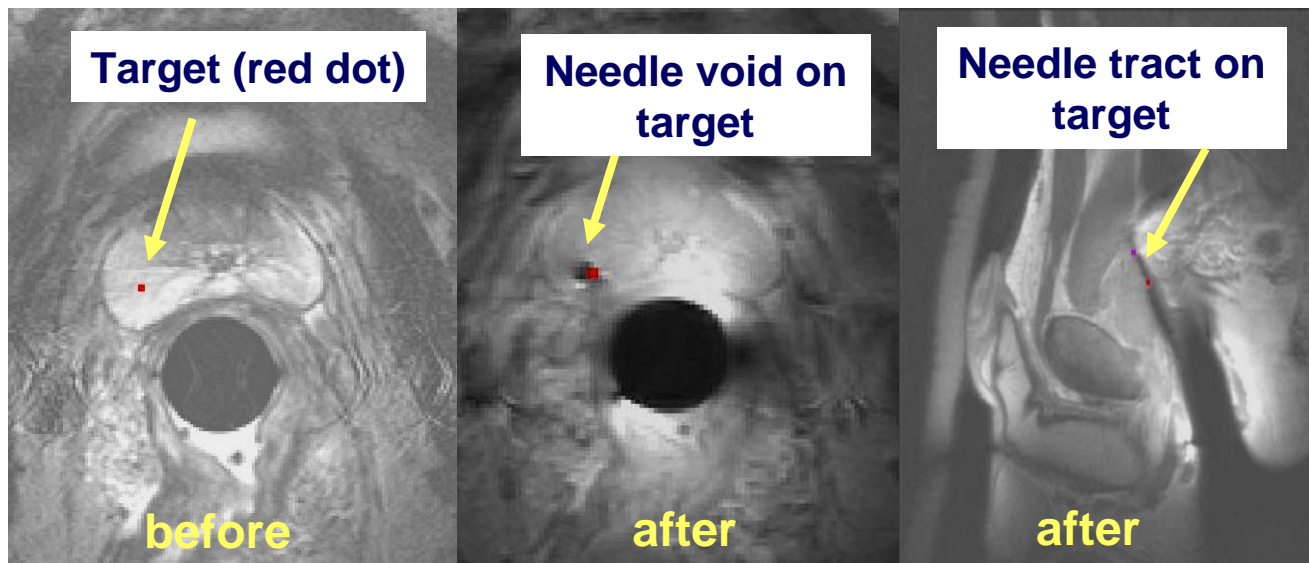
Results in multiple Ph1 clinical trials

- From concept to trials in 22 month
- 38 biopsies and seed placements
- Accuracy ~3 mm
- No severe adverse events

Example #2



Example #1



Project #2: Transperineal interventions in closed MRI

Engineering:

Brigham and Women's Hospital

Johns Hopkins University

Acoustic Medsystems/Burdette Medical

Clinical:

Brigham and Women's Hospital

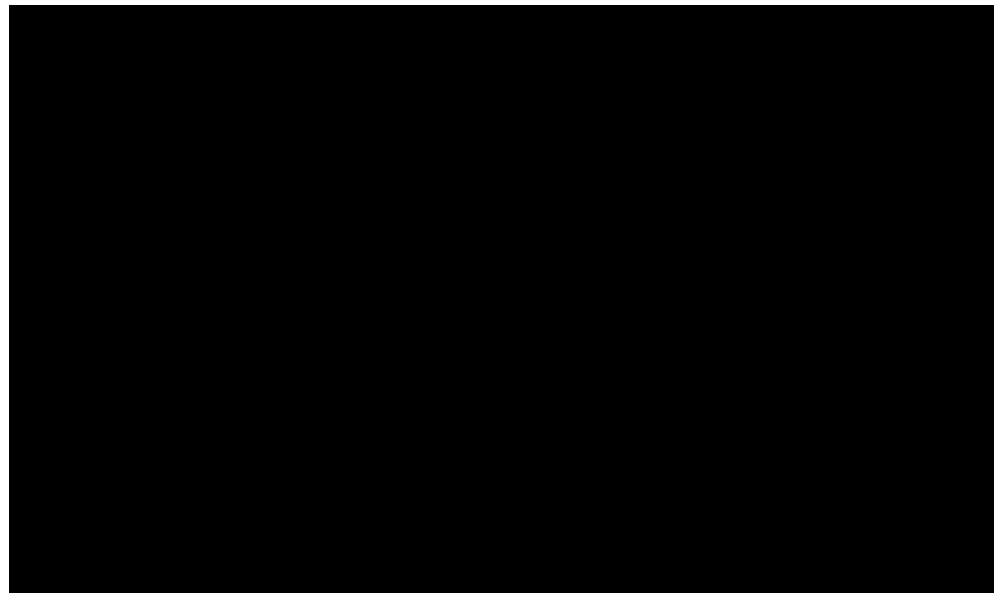
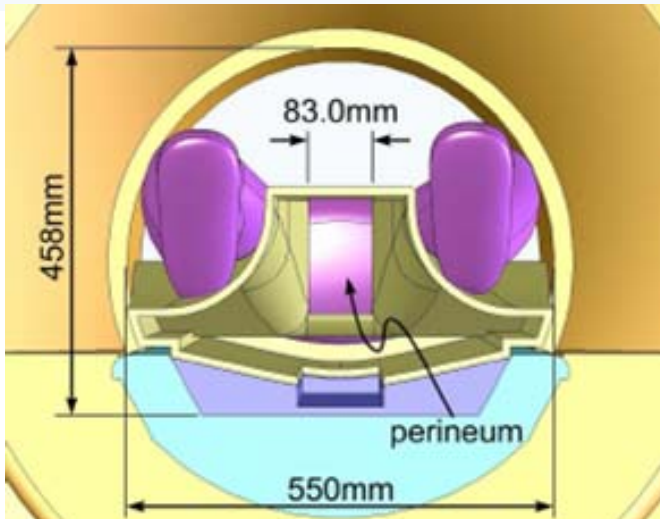
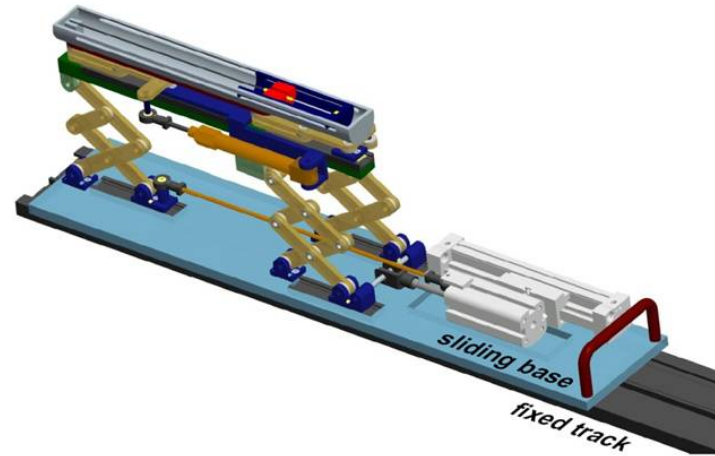
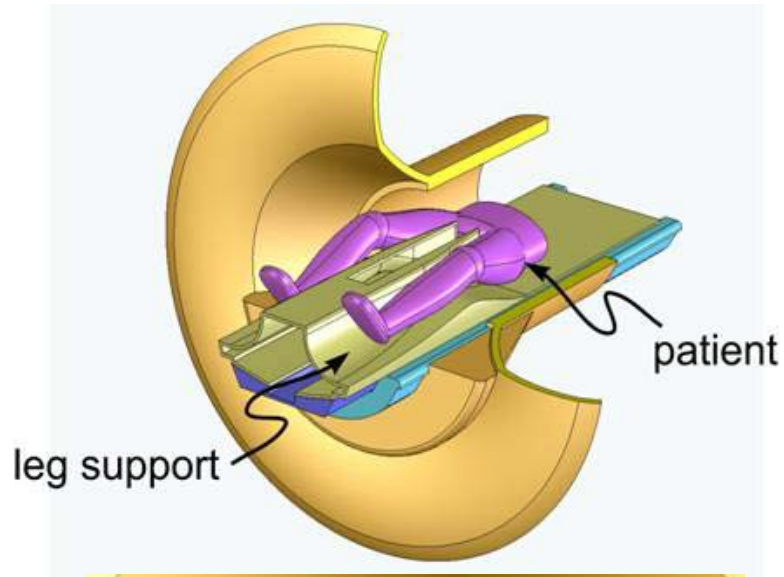
Funding

NIH/NCI 1R01CA111288-01, PI Tempny (5 more years)

DoD PC061118, PI, Fischer (2 more years)



In-scanner robotic assistant



G. Fichtinger, 2006

DiMaio *et al.* IEEE BioRob, 2006; Fischer *et al.* IEEE ICM, 2006

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Project #3: Transperineal brachytherapy under TRUS

Engineering:

Johns Hopkins University
Acoustic Medsystems/Burdette Medical

Clinical:

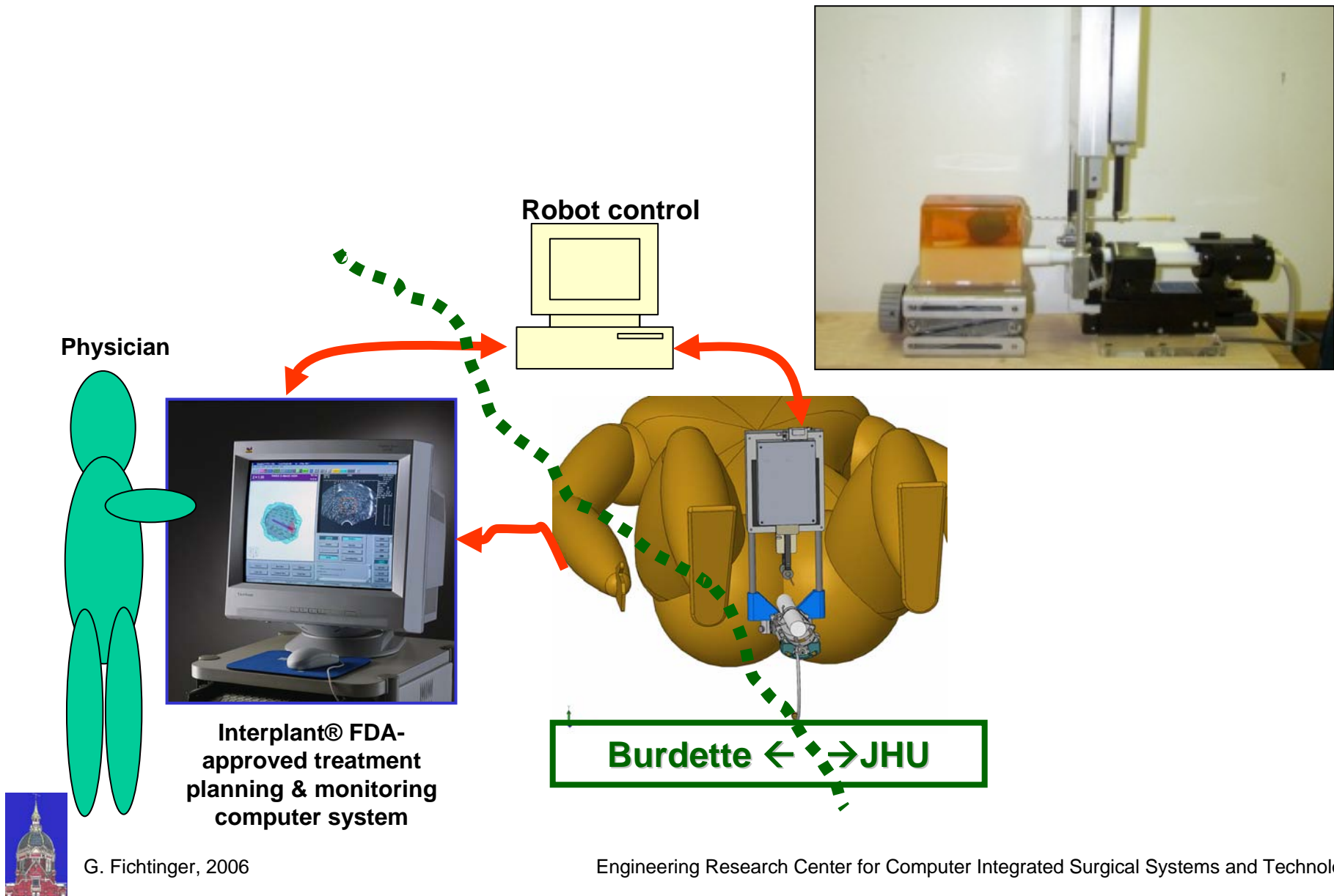
Johns Hopkins University

Funding

NIH/NCI 2 R44 CA099374-02, PI Burdette (3 more years)
NIH/NCI 1R21CA120232-01, PI Salcudean (2 more years)
DoD PC 050042, PI Song (1 more year)
NIH/NCI 5R44CA088139-04, PI Burdette (expired)
NIH/NCI 1R43CA099374-01, PI Burdette (expired)
NIH/NCI R01, PI Fichtinger – in submission



(1) TRUS-guided robotic assistant

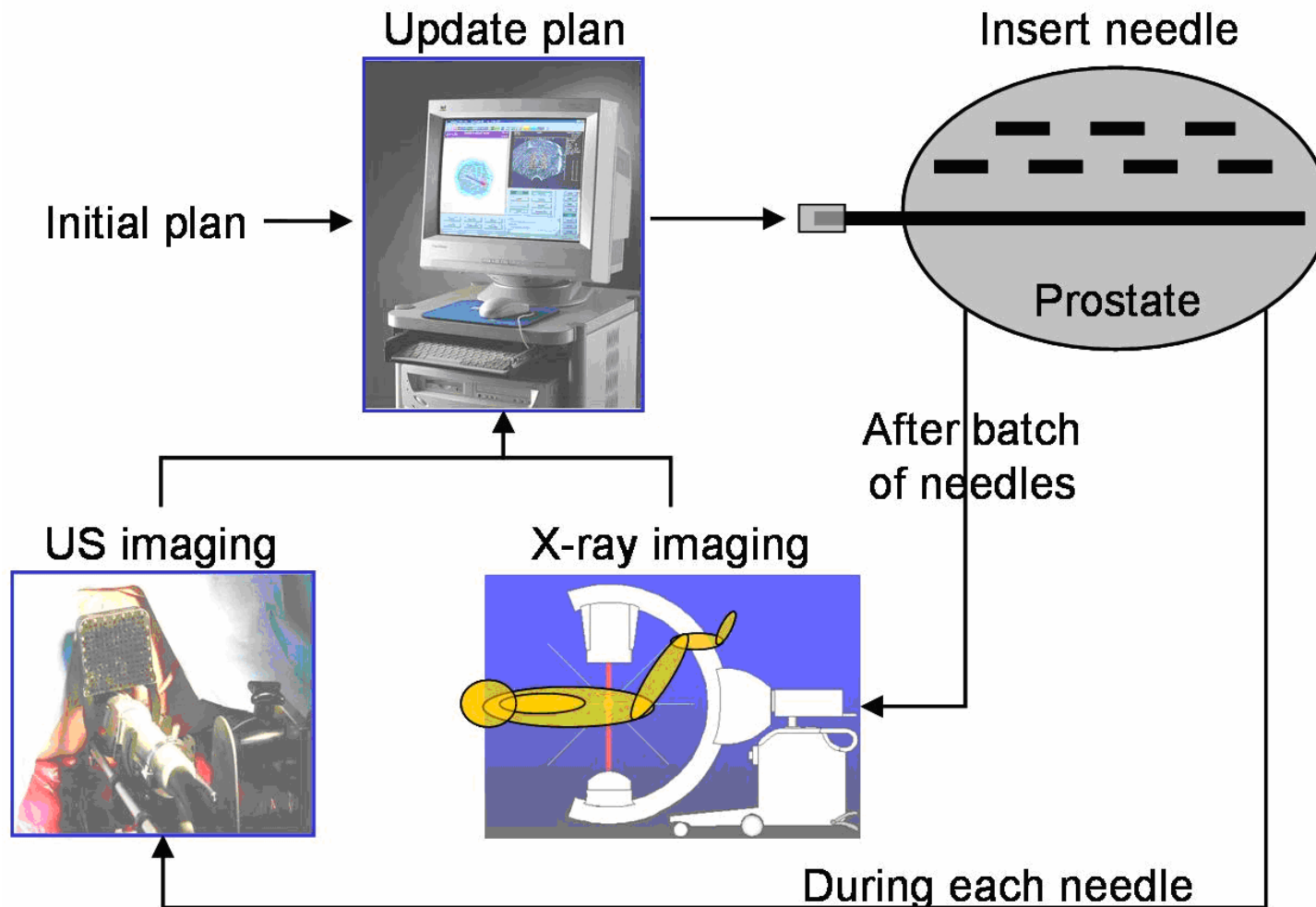


G. Fichtinger, 2006

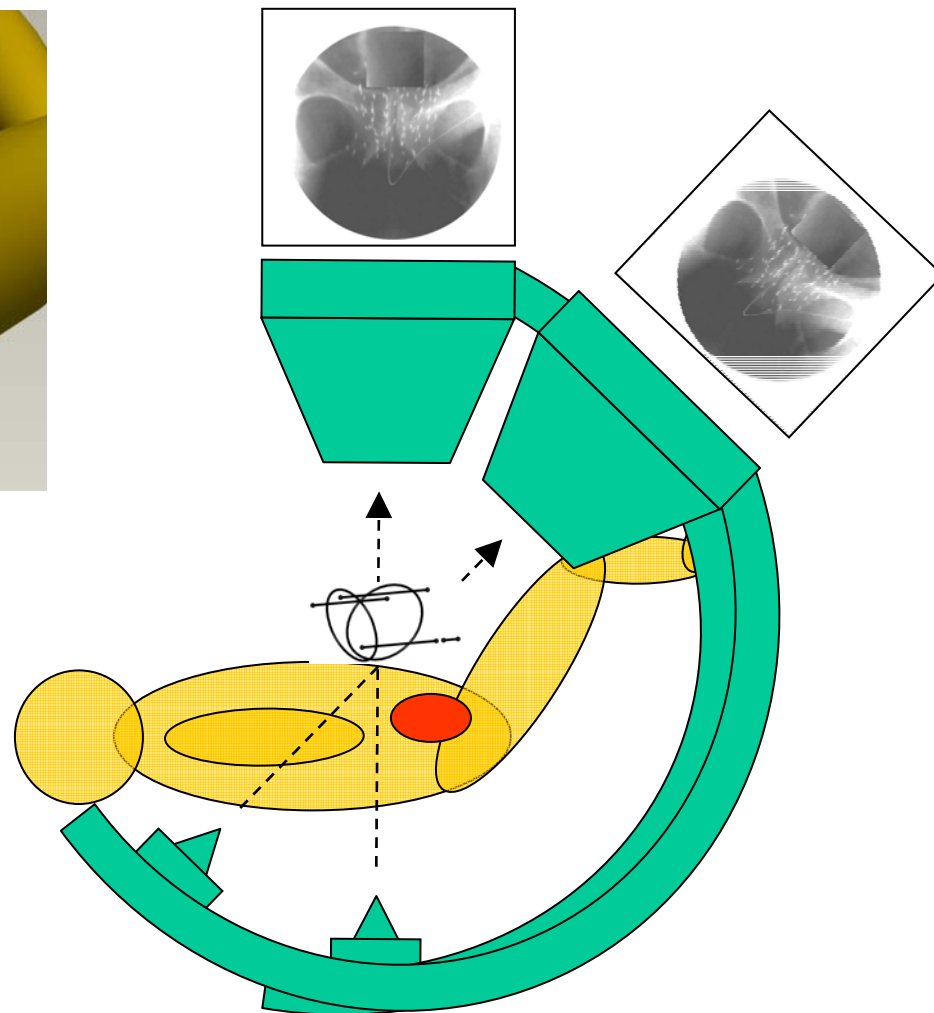
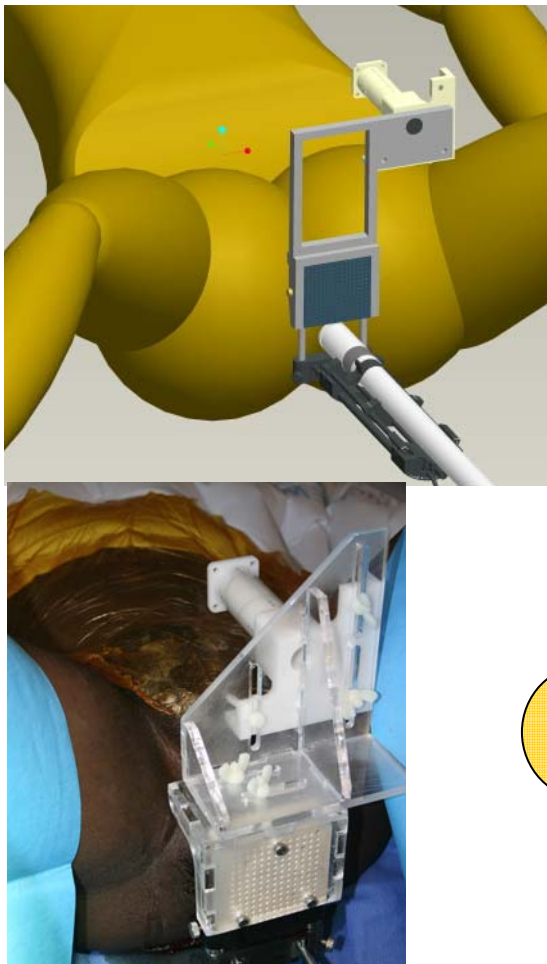
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(2) Intra-operative dosimetry & optimization



RUF - Registration of Ultrasound and FLuoro



Project #4: Transrectal HIFU ablation under TRUS

Engineering:

Johns Hopkins University
Acoustic Medsystems/Burdette Medical

Clinical:

Johns Hopkins University

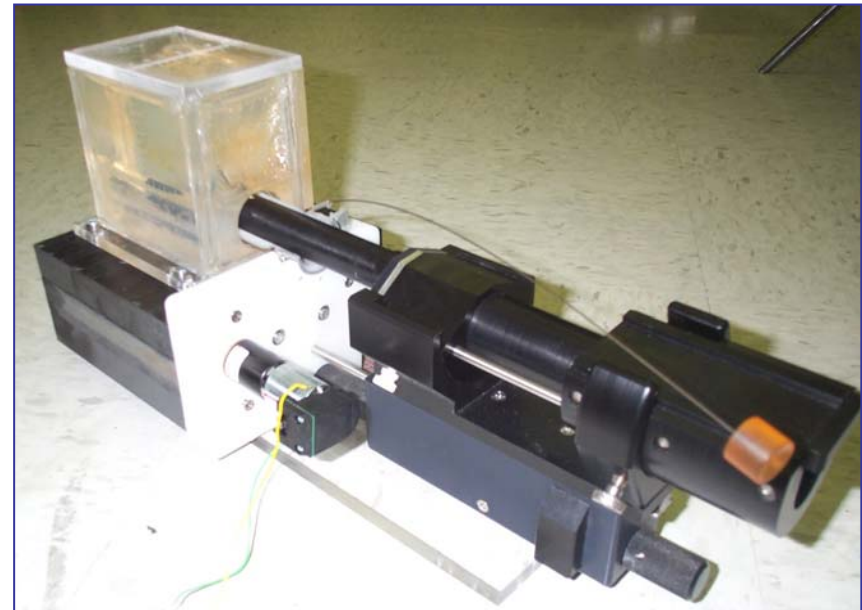
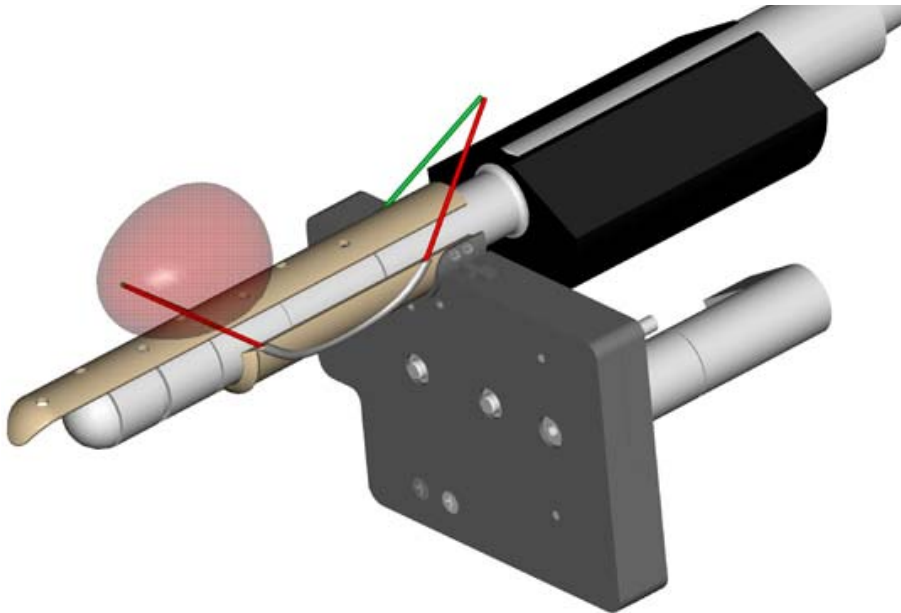
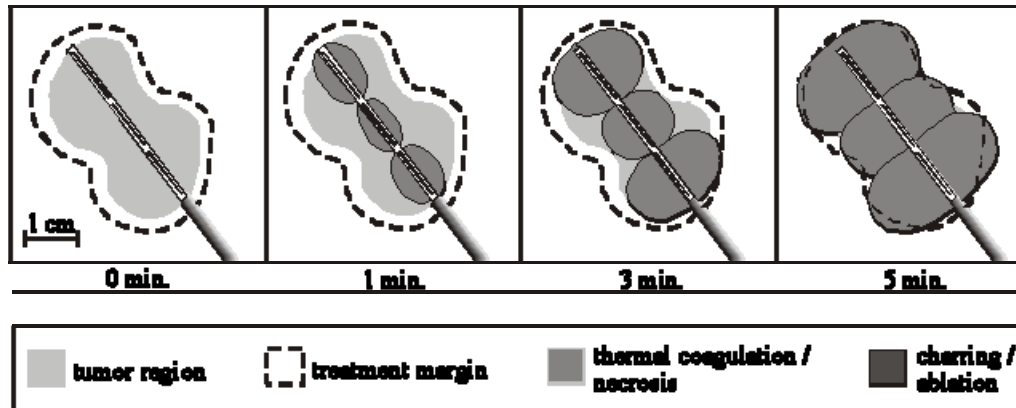
Funding

NIH/NCI 1R41CA106152-01A1 , PI Fichtinger (to expire)



TRUS-guided robotic assistant

ACOUSTIC[®] (Ultrasound)



Perennial image processing themes

- Segmentation in TRUS and MRI
- Deformable registration of the prostate with ultrasound series, with MRI series, and across these
- Multi-dimensional statistical deformable atlas of the prostate, with associated probabilities of cancer and other clinically quantities
- Segmentation, tracking, and measurement of therapeutic substances used in prostate therapies, such as radioactive seeds, injections, etc, in ultrasound, MRI
- Reconstruction of brachytherapy implants in C-arm fluoroscopy
- Segmentation and tracking of surgical tools, such as needles and tissue ablaters, in ultrasound and MRI



Current state in clinical systems

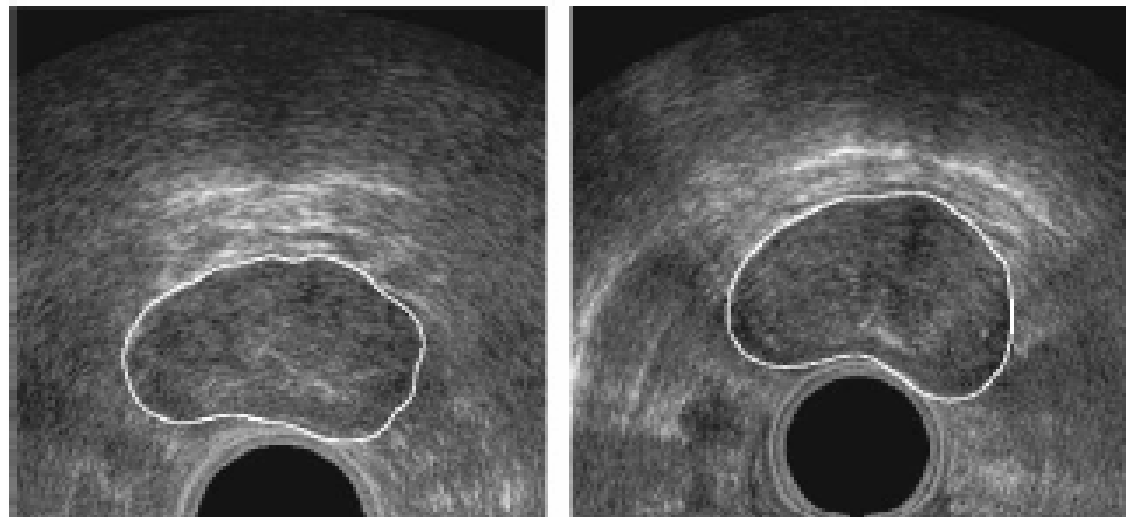
- Manual/semi-manual segmentation
- Contour-based registration

- PROS: excellent clinical control, safety
- CONS: extremely time consuming



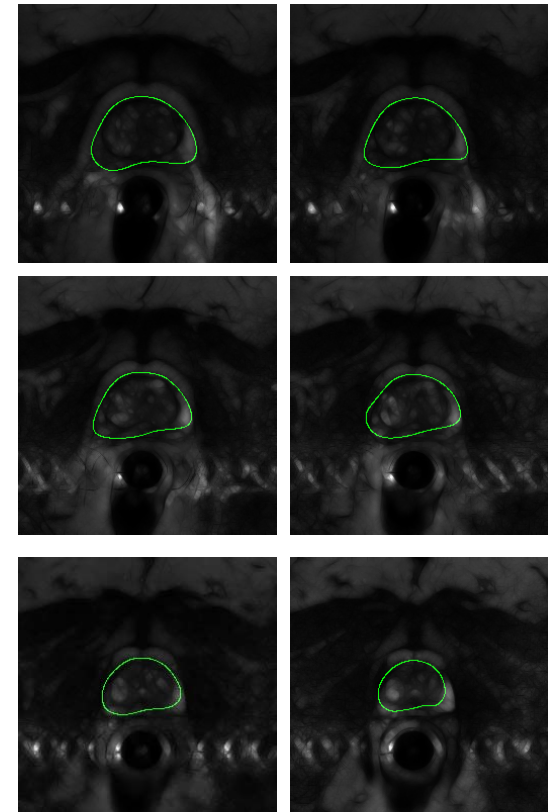
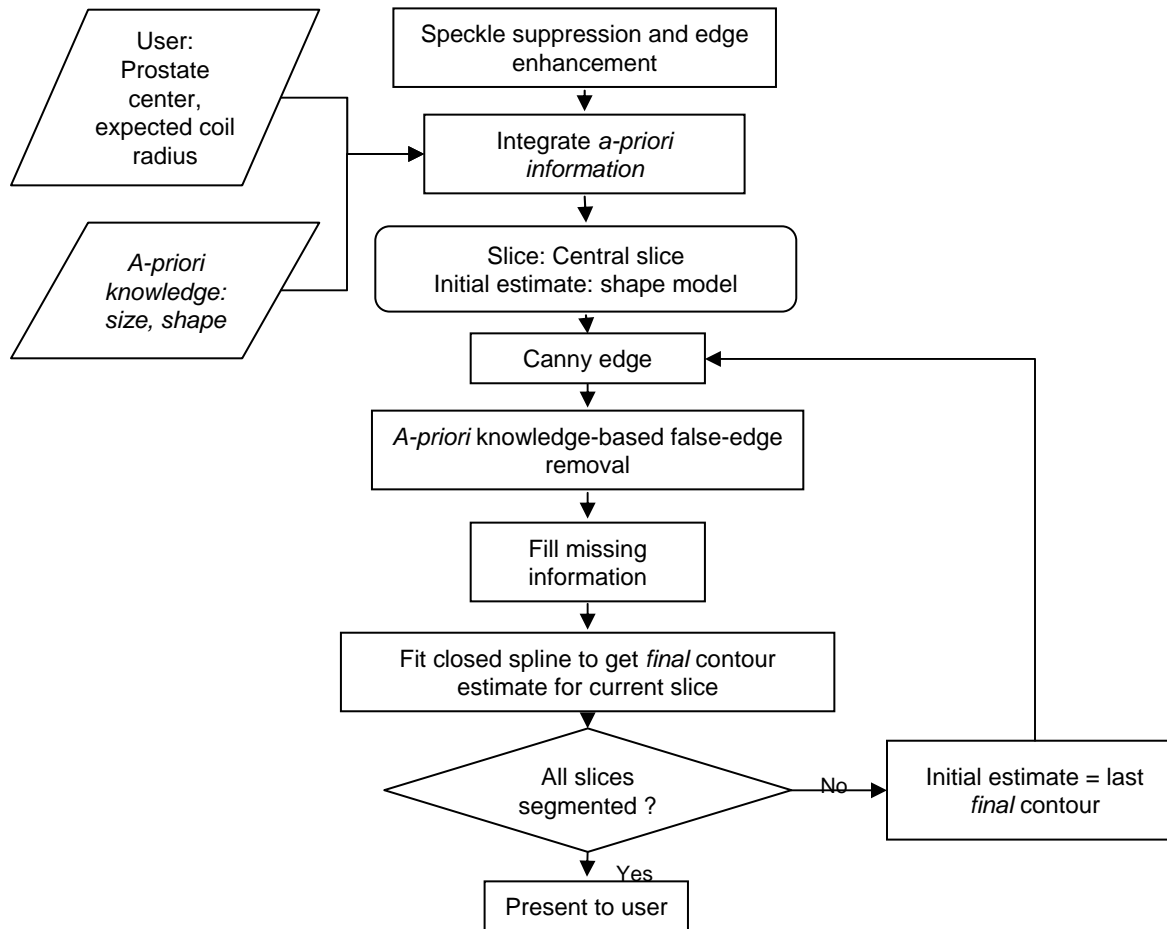
Example: current state in TRUS segmentation

IMM/PDAF by Abolmaesumi



Example: current state in MRI segmentation

Atlas based segmentation by Vikal



Perennial issues in system integration

- GUI
 - Old Slicer did not work out
 - Current clinical systems use custom GUI
 - Industry legacy – Burdette Interplant®
- Open source – potential IP issues for industry partner



Questions?



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